

**Mineralogy, Geochemistry and Health Impacts of Earth
Materials Consumed by Humans in Vhembe District, Limpopo
Province, South Africa**

By

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Submitted in Partial Fulfilment of the Requirements for the Degree of Doctor of
Philosophy in the Subject of Environmental Sciences (Geology) at the
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Submitted on 19th April 2013

ABSTRACT

This work focuses on three main themes (clay mineralogy and geochemistry, bioaccessibility of essential nutrients and effects of eating Earth materials on human health), treated in five chapters. The first theme of the study assessed the prevalence of geophagic practice in the area. Issues examined were demography, rationale for eating Earth materials or dirt and distribution chain of consumed Earth material in the District. Purposive sampling was used to identify 438 women who practice geophagy in the area. Forty six point three percent of the women were married, 45.4% were single, 4.3% were divorced and 3.2% were widowed. The reasons they gave for geophagic practice are medicinal, quelling of nauseate feelings and control of early morning sickness in pregnancy. Clays and soft stone are the most preferred types of Earth material. Average daily ingestion rate for pregnant women was 90 g per day while non- pregnant women consume an average of 40 to 60 g on a daily basis.

Features of geophagic materials were assessed with a view to ascertain if these features could assist in the understanding of these geophagic materials to perform some of the functions that have been adjudged for human geophagic practice. Tests conducted include: colour, pH, electrical conductivity (EC), cation exchange capacity (CEC), textures and occurrence of beneficial bacteria in the samples. Colour ranged from red, yellow to dark grey through various shades of brown. The pH of the geophagic materials ranges from 4.30 to 7.90. The values obtained for EC ranges from 8.22 $\mu\text{S}/\text{cm}$ to 652 $\mu\text{S}/\text{cm}$ while CEC ranges from 3.74 meq/100g to 19.78 meq/100g. On the basis of texture, the consumed Earth materials were classified as clays, sandy clay loam and silty clay materials. Significant growths of filamentous bacteria (*Streptomyces*) were recorded in some geophagic materials from the District. Aggregates of grey, brown and whitish bacteria colonies were observed on the rim of the plates.

The third part of the study focused on an investigation of the potential of these geophagic materials to supplement the mineral nutrients of geophagists. The oral bioaccessibility using *in vitro* physiologically based extraction test (PBET) was used. A simplified, two-stage extraction simulating the human stomach (pH 1.2 – 1.7) and intestine (pH 6.3 – 6.5) was developed and applied to 30 geophagic samples. Extractants were analysed by inductively coupled plasma mass spectrometry (ICP-MS). The element concentrations extracted from geophagic materials within the human stomach and intestine respectively were on average 0.90 and 0.20 ppm Fe; 81.44 and 22.42 ppm Zn; 10.10 and 9.02 ppm Se; 1672.7 and 1900

ppm Mn; 24.93 and 230.04 ppm Cu; 11.73 and 11.72 ppm Co; 2.22 and 3.23 ppm As; 29.50 and 35.91 ppm V; 5.59 and 102.87 ppm Cr; 5.53 and 21.28 ppm Ni; 0.09 and 0.05 ppm Cd; 5.52 and 6.72 ppm Pb. Iron, Zn, Mn and Cd bioaccessibilities were found to be higher in the stomach while Cu, V, Cr, Ni, Hg and Pb bioaccessibilities were found to be higher in the intestinal phase. Bioaccessibilities of Se, Co and As were similar in the stomach and intestinal phases. The fourth aspect of this study focuses on the implications of eating Earth on human health in Vhembe District. Haemoglobin levels in blood of non-pregnant geophagic women were measured and identification of helminth ova in 30 geophagic samples and 3 non-geophagic samples were investigated to confirm the possible role of geophagy in causing iron deficiency anaemia and in the transmission of geohelminths (*Ascaris lumbricoides*, *Trichuris trichuria*, *Stongyloides stercoralis* and Hookworm). Sixty eight non-pregnant geophagic women between the ages of 18 and 49 and five non-pregnant women that do not practice geophagia between the ages of 18 and 45 (control group) were recruited into the study. Forty four percent of the geophagic women were diagnosed as anaemic and 56% were normal. All the women in the control group were normal. An *Ascaris lumbricoides* ovum was detected in sample 21 of the geophagic material.

The fifth aspect deals with determination of minerals in consumed Earth materials. Thirty five samples of consumed Earth materials and three non-geophagic clays were analysed for their mineralogical composition using x-ray diffractometer (XRD). The concentrations of major and trace elements were determined by means of x-ray fluorescence spectrometry (XRFS). The clay mineralogy showed that consumed Earth materials consist of kaolinite, smectite, muscovite, quartz, albite, orthoclase, goethite, hematite, microcline and anatase. Result of Tukey's post hoc test mineralogy showed that only kaolinite has a significant percentage with respect to all other minerals. The consumed Earth materials are richer in kaolinite (samples 1, 4, 7-9, 11-23, 24-30) with a lesser percentage of quartz than non-consumed Earth materials. Major element chemistry of the consumed Earth materials are enriched in Fe and Al and depleted in Ca, K and Mn. The chemical index of alteration (CIA, concentration of elements in soils and rocks) for the consumed Earth materials ranges from 17.09 – 99.07. Kaolin is the dominant mineral in the consumed Earth material; and because of its ability to coat and adhere to intestinal membrane of geophagist, this could suggest that pregnant women, lactating mothers and children indulge in geophagic practice to seek various forms of protection against gastrointestinal problems and toxins.